NASA TECH BRIEF
Lewis Research Center

Fabrication Techniques for Thoria-Dispersed (TD) Nickel

Thoria-dispersed (TD) nickel alloys have a unique combination of high temperature strength and high thermal conductivity that other nickel-base superalloys do not possess. These high temperature properties are derived from the presence of very small thorium oxide particles distributed throughout the nickel metal matrix. However, it is the presence of these particles that makes the fabrication of such alloys difficult. For example, TD nickel is difficult to weld because the thoria, which is typically only 2% by volume dispersed uniformly throughout the 98% volume of nickel, tends to agglomerate in the locally heated region during welding. This results in a loss of strength in that region and in a relatively weak weld.

TD nickel is usually produced in sheet form from powdered metals. Normal thicknesses are 0.32 cm or less; however, sheets 0.64 cm thick can be procured on special order.

For the first time, large parts were successfully spun from TD nickel sheets 0.64 cm thick. Cylindrical rocket thrust chamber sections were fabricated from single disks of TD nickel, 61 cm in diameter and 0.64 cm thick, by using the following techniques. Both the combustion chamber sections and the nozzle sections were made by spin forming techniques (which are proprietary methods of Tri-Metals Company). The chamber sections were 14.6 cm in diameter by 47 cm long; the nozzle sections were 14.6 to 41.3 cm in diameter by 23 cm long.

The combustion chamber and nozzle sections were then successfully welded together circumferentially to form a rocket motor with a 16:1 nozzle extension (using welding techniques previously developed by Bell Aerospace Co.). An automatic gas tungsten arc welder was used, and the heat input to the weld region was carefully controlled. Hastelloy-X was used as the filler material and was essentially cast into the weld area. Metallographic examinations of weld samples showed a minimum agglomeration of the thoria in this region. The weld strength was essentially limited, however, by the strength of the Hastelloy-X. Although slightly weaker than the TD nickel, the weld permitted a larger rocket motor to be made than would otherwise have been possible.

Coolant passages for the regeneratively cooled thrust chamber have varying widths and heights, and were machined into the rocket motor by electrical discharge machining. An optimized coolant passage for such a regeneratively cooled thrust chamber has a variable cross-sectional area that produces the maximum required coolant heat transfer coefficient and the minimum pressure drop consistent with that coefficient. Mechanical machining of such passages would require three-dimensional cutting. With electrical discharge machining, shaped and contoured graphite electrodes could be used to cut the coolant passages. Careful control of the equipment, the flushing procedure, and the electrode dressing resulted in uniform coolant passages of the prescribed dimensions and surface finish.

Notes:

1. The following documentation may be obtained from:

    National Technical Information Service
    Springfield, Virginia 22151
    Single document price $3.00
    (or microfiche $0.95)

    Reference:
    NASA-CR-72742 (N71-14135), Investigation of Advanced Thrust Chamber Design

(continued overleaf)

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B71-10369

Patent status:

No patent action is contemplated by NASA.

Source: Bell Aerospace Co. and
Tri-Metals Co. (now C.S. Industries)
under contract to
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